FEDERAL HIGHWAY ADMINISTRATION

Long Term Pavement Performance
Specific Pavement Studies

ARIZONA SPS-9A
I-10 Westbound, Mile Post 112-123

Construction Report on Site 04B900
Arizona Department of Transportation

FINAL

Prepared by:

Western Region Contractor
Nichols Consulting Engineers, Chtd.
1885 S. Arlington Ave., Suite 111
Reno, Nevada 89509

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INTRODUCTION

The Long Term Pavement Performance (LTPP) SPS-9 experiment program was originally designed to provide field validation of the Superpave asphalt binder specification and mix design procedures. Subsequently, the SPS-9 experiment was split into two related experiments -- SPS-9A and SPS-9B. The SPS-9A experiment is the first part of a multistage approach to validate the Strategic Highway Research Program's (SHRP) Superpave Asphalt Binder Study. SPS-9B was to focus on pavement structural factors and the Superpave performance prediction models. Premature pavement failure due to numerous site specific variables is a common problem across the country. Most highway agencies have developed a standard asphalt paving mix which they use for highway construction throughout the State/province. This study is designed to develop a method that will produce guidelines for pavement design that is site-specific, taking into account the traffic, environment, and pavement type. An asphalt pavement mix that utilizes site specific variables should decrease the risk of many premature pavement failures.

The project reported here was the third SPS-9 project constructed in Arizona and was the first true SPS-9A project in Arizona. The general LTPP project identification number is 04B900

SPS-9A Objectives

The primary objectives of the Superpave Asphalt Binder Study experimentation are:

- To evaluate and improve the practical aspects of implementing the Superpave program through hands-on field trials by highway agencies.
- Compare the performance of the Superpave mixes with mixes designed with current highway agency practices.
- Provide long-term performance data for evaluation and refinement of the Superpave specifications and design procedures.
- Test the sensitivity of the Superpave asphalt binder specifications for distress factors such as fatigue, low temperature cracking, and permanent deformation.
- Provide highway agencies the opportunity to evaluate the performance of other experimental modifications by the construction of supplemental sections.

The SPS-9A experiment requires construction of a minimum of three test sections at each site that will include the highway agencies' standard mix; the Superpave level 1 designed standard mix and the Superpave mix with an alternative binder. The alternative binder is defined as a binder with a grade either higher or lower than the required Superpave binder such that the performance characteristics of interest may be expected to exhibit distresses earlier than the Superpave binder section. The pavement structure and thicknesses of layers containing the three experimental mixtures should be the same on all test sections.

Project Background

This report documents the construction of an SPS-9A project in Arizona, 04B900. Details of the construction are provided in the sections to follow. The project was a portion of Interstate 10 westbound near Phoenix, Arizona. The experimental project consists of nine test sections, three SPS-9A sections, and six State supplemental sections, each constructed 1.6 km in length on the existing pavement. Construction of the surfacing on the test sections occurred in March 1995.

Although a total of nine experimental sections were constructed, this report only documents the materials and construction utilized on the three LTPP test sections (04B901, 04B902, and 04B903). Time and budget constraints placed on the LTPP Western Regional Coordination Office Contractor (NCE) did not allow for detailed information to be recorded on the supplemental sections.

Two Superpave PG-graded binders, PG76-10 and AC-40 (also meeting PG70-10), were utilized on the two Superpave sections and a PG76-10 asphalt cement was utilized on the agency standard mixture. A Superpave level 1 mixture design method was used on the Superpave sections, while the agency standard mixture was designed according to Marshall 75 blow mixture design.

PROJECT DESCRIPTION

Figure 1 illustrates the location of the SPS-9A project. The project is located on Interstate 10 westbound between milepost 112.72 and 122.29. All sections were milled 7.3-m wide to a depth of 102 mm and replaced with a course 38-mm top size aggregate prior to construction of the experimental surfacings.

Based upon the SHRPBIND program developed by LTPP and climatic data from nearby weather stations, the mean annual low air temperature is -7°C, the mean 7-day high air temperature is 47°C, the freezing index is 0, and the average annual precipitation is 226 mm. Thus, the site is classified as being in a dry no-freeze climatic zone.

This is a resurfacing overlay project. The designed rehabilitated pavement structure is 76 mm of asphalt concrete placed over existing pavement. Figure 2 indicates the typical "as-built" rehabilitated pavement structure. Design traffic rates as reported by the Arizona Department of Transportation (ADOT) are:

Annual Average Daily Traffic (two directions)	30,000
Percent Heavy Trucks and Combinations (percent of AADT)	25
Est. 18K ESAL Rate in Study Lane (1,000 ESAL/Year)	1,600
Total Design 18K ESAL Applications in Design Lane	31.5×10^6

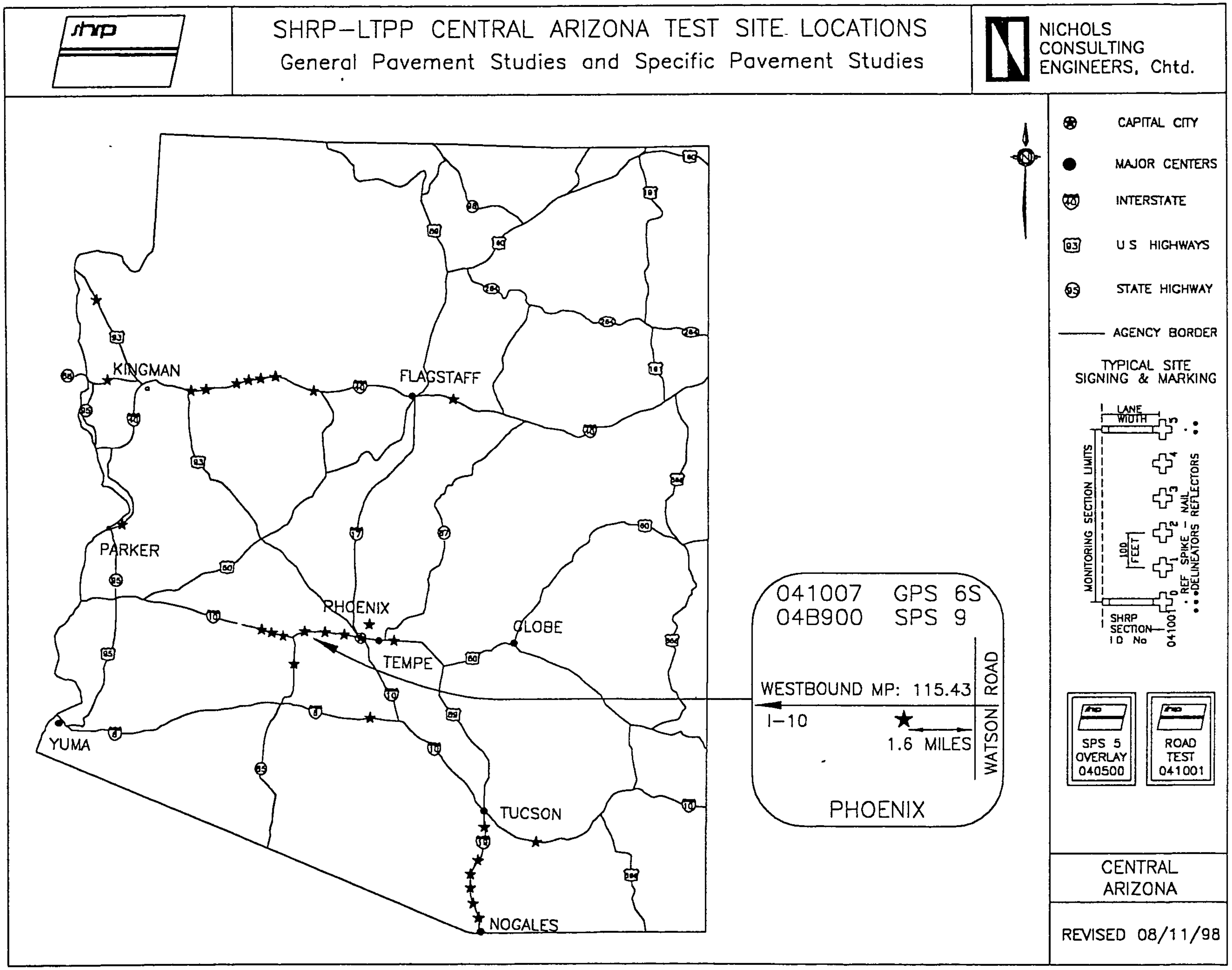

Figure 1. Location of Arizona SPS-9A project 04B900.

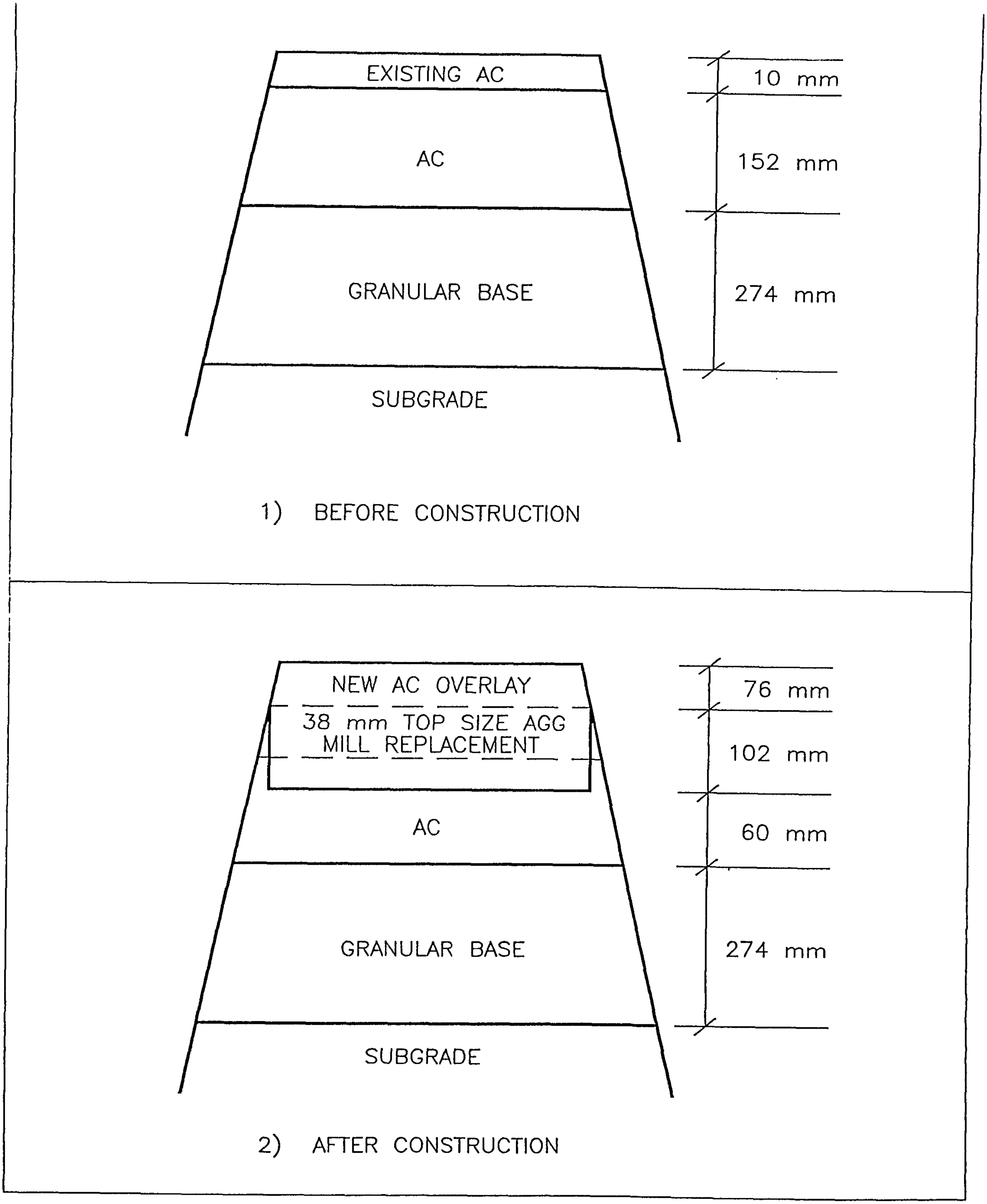

Figure 2. The typical "as-built" rehabilitated pavement structure.

Figure 3 indicates the layout of the test sections. Each experimental mixture was constructed in a 1.6-km long segment of which a 152-m test section length was established. All test sections were constructed between project stations 5945+00 and 6448+00. The actual monitoring portions of the test sections are located as illustrated in figure 3 and documented in table 1.

CONSTRUCTION OPERATIONS

A summary of the complete paving operation is provided in this section of the report. Detailed below are the prepaving operations, discussions regarding the asphalt concrete (AC) mixture designs, summaries of the paving operation, and information concerning the additional materials sampling and testing performed on the test sections. The paving subcontractor on this job was Staker Construction Co. from Salt Lake City, Utah.

Mr. Lonnie D. Hendrix, representing Arizona DOT, and Mr. Pierre F. Pradere, representing Nichols Consulting Engineers and the LTPP Western Region, were on site during all Superpave paving operations.

Prepaving Operations

As mentioned earlier, this is an overlay project over the existing pavement. Prior to construction of the test sections, all sections were milled 7.3-m wide to a depth of 102 mm and replaced with a coarse 38-mm top size aggregate.

Asphalt Concrete Mixture Designs

On this project, the Superpave mixture designs were the responsibility of the contractor. Staker Paving & Construction Co. had contracted with Applied Paving Technology, Inc. to perform the required Superpave mixture designs. Mixture designs consisted of a Superpave design having a 19.0 mm nominal maximum aggregate size designed in accordance with Superpave Asphalt Mix Design Specifications and Asphalt Institute Superpave Series No. 2 (SP2). Two Superpave mixes were designed, and both mixes were identical except the asphalt binder type. The agency standard mixture was designed by the Arizona DOT central materials laboratory using the Marshall mixture design method. Complete mixture designs for Superpave mixes are provided in reference [1].

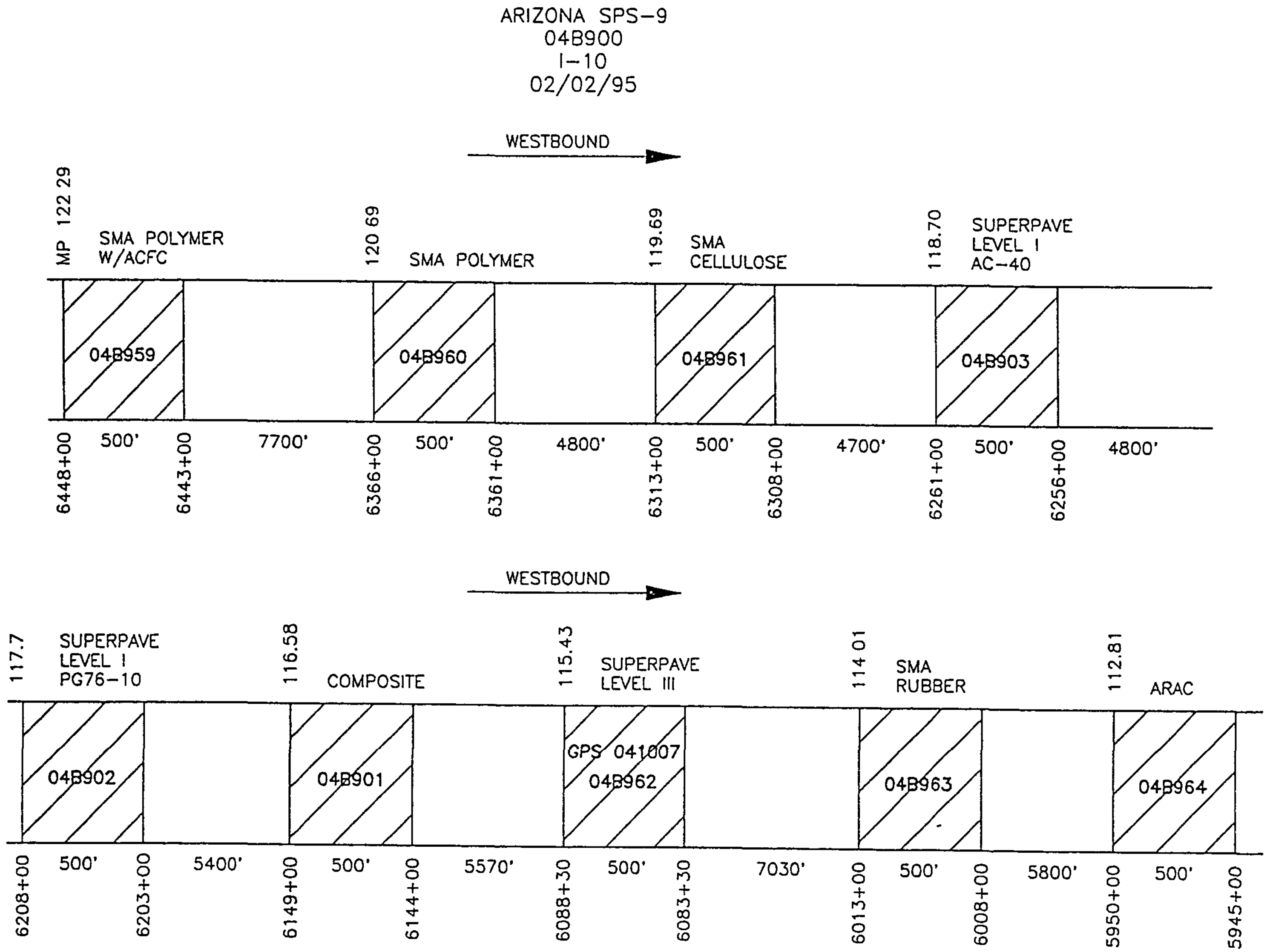

Figure 3. SPS-9A (04B900) test section layout.

Table 1. Test section layout.

Site	Location	Construction Stationing (ft)	Test Section (ft)	Description
04B964	Begin sampling area	5944+00	-1+00	State Supplemental Section
	Begin monitoring	5945+00	0+00	
	End monitoring	5950+00	5+00	
	End sampling area	5951+00	6+00	
04B963	Begin sampling area	6007+00	-1+00	State Supplemental Section
	Begin monitoring	6008+00	0+00	
	End monitoring	6013+00	5+00	
	End sampling area	6014+00	6+00	
04B962	Begin sampling area	6082+00	-1+00	State Supplemental Section
	Begin monitoring	6083+00	0+00	
	End monitoring	6088+00	5+00	
	End sampling area	6089+00	6+00	
04B901	Begin sampling area	6143+00	-1+00	Agency Standard PG 76-10
	Begin monitoring	6144+00	0+00	
	End monitoring	6149+00	5+00	
	End sampling area	6149+15	5+15	
04B902	Begin sampling area	6202+00	-1+00	Superpave Level 1 PG 76-10
	Begin monitoring	6203+00	0+00	
	End monitoring	6208+00	5+00	
	End sampling area	6209+00	6+00	
04B903	Begin sampling area	6255+00	-1+00	Superpave Level 1 PG 70-10
	Begin monitoring	6256+00	0+00	
	End monitoring	6261+00	5+00	
	End sampling area	6262+00	6+00	
04B961	Begin sampling area	6307+00	-1+00	State Supplemental Section
	Begin monitoring	6308+00	0+00	
	End monitoring	6313+00	5+00	
	End sampling area	6314+00	6+00	
04B960	Begin sampling area	6360+00	-1+00	State Supplemental Section
	Begin monitoring	6361+00	0+00	
	End monitoring	6366+00	5+00	
	End sampling area	6367+00	6+00	
04B959	Begin sampling area	6442+00	-1+00	State Supplemental Section
	Begin monitoring	6443+00	0+00	
	End monitoring	6448+00	5+00	
	End sampling area	6449+00	6+00	

Superpave Mixture Design

Two binders were used in the Superpave mixture design. One was AC-40 (also meeting a PG70-10) provided by Koch Asphalt. The other one was PG76-10 provided by EOTT/Neste Oil. Only level 1 volumetric mixture designs were performed and a Pine gyratory compactor was utilized for the mixture designs.

A 25.4 mm maximum size of aggregate gradation was blended using stock pile samples provided by Staker Paving & Construction Co. The specific gravities of the gradation used in the mix design are shown in table 2. The gradation chart is also provided in figure 4. As indicated, the gradation is on the coarse side of the curve and falls below the forbidden zone.

Table 2. Specific gravities of combined mineral aggregate, Superpave mixture design.

Bulk Specific Gravity of Aggregate, Gsb (aggregate)	2.672
Bulk Specific Gravity of Admixture, Gsb (admixture)	3.140
Bulk Specific Gravity of the Total Gradation, Gsb (total)	2.677
Effective Specific Gravity of the Total Gradation, Gse (total)	2.712

In addition, a type II portland cement supplied by ADOT through Sunbelt Cement Inc. was used as a mineral admixture. The amount of the admixture was 1 percent by total weight of the aggregate blend.

Two different gradations were evaluated at three AC contents (4.0 percent, 4.4 percent, and 5.0 percent) and the results are summarized in table 3. Detailed information on the two mixes evaluated for the Superpave mix design are shown in reference [1].

Table 3. Summary of mixture.

Mixture Components	Section	
	04B902	04B903
Binder	PG76-10	AC-40
AC Content, %	4.3	4.3
Air Voids, %	4.0	4.0
Gradation	GR1	GR1
Max. Particle Size, mm	25.4	25.4

Agency Standard Mixture Design

Section 04B901 (Agency Standard) was designed following the standard practices of Arizona DOT: a Marshall Method of Mix Design as outlined in the latest edition of the Asphalt Institute Manual Series No. 2 (MS-2) and ASTM D 1559 (75 blow). This test section was meant to serve as a control section and represent standard mixtures, materials, and construction practices typically utilized for highway construction in Arizona.

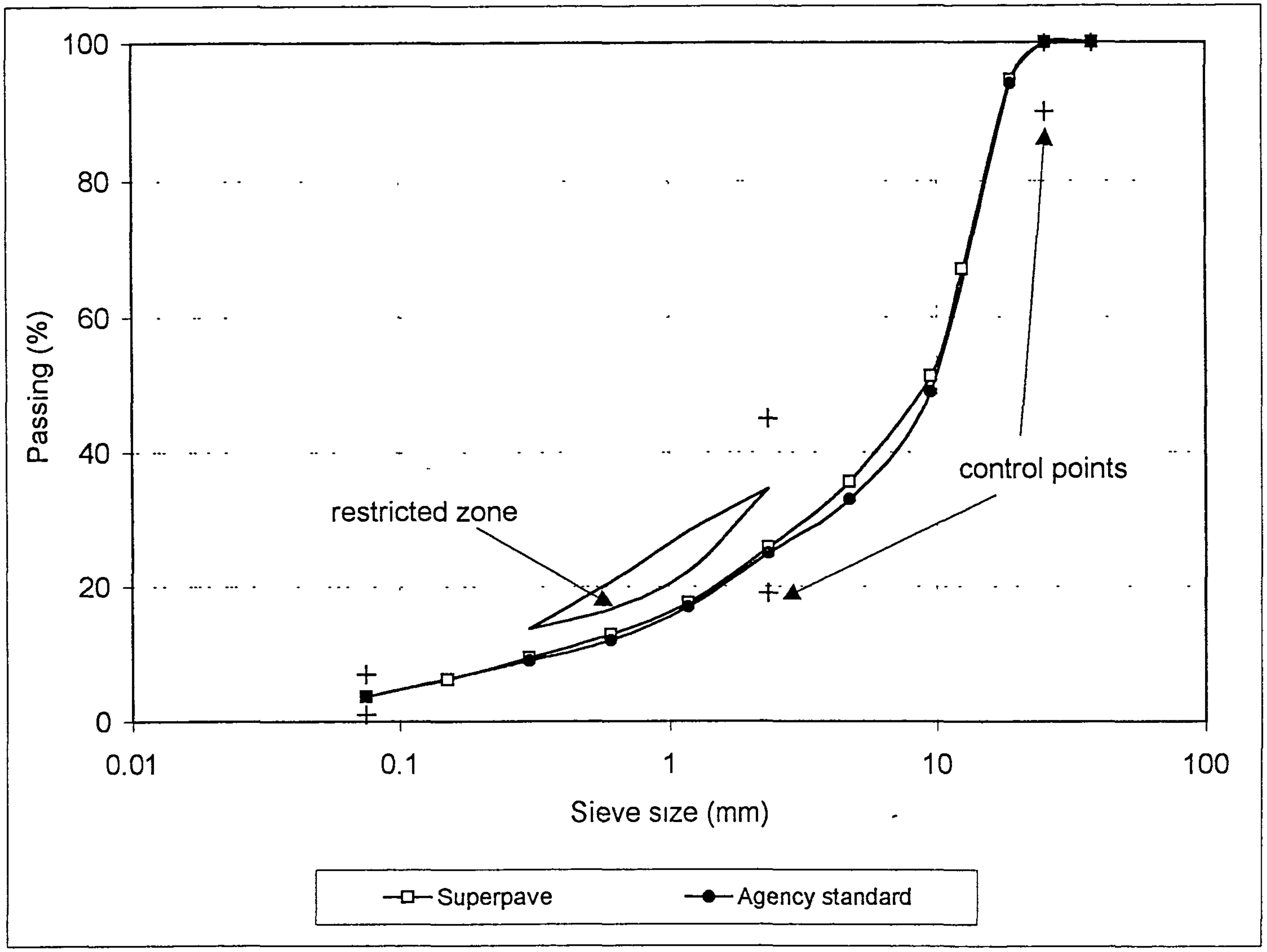

Figure 4. Gradations of Superpave aggregate and agency standard aggregate.

Aggregate for this mixture is comprised of coarse aggregate, fine aggregate, and mineral filler. Mix design aggregates were targeted as follows:

- 75 percent coarse aggregate
- 25 percent fine aggregate

A Portland cement was used as a mineral admixture. The amount of the admixture was one percent by total weight of the aggregate blend. A blended gradation is provided in figure 4.

A performance grade PG76-10 asphalt cement was used for this mixture design. Mixture properties are presented in table 4.

Table 4. Summary of agency standard Marshall mixture properties.

Marshall Properties	Mix Design Results
AC Content (%)	3.8
Bulk Density (kg/m^3)	2368
Rice Density (kg/m^3)	2483
Marshall Voids (%)	6.0

Paving Operations

For sections 04B903 and 04B902, the passing lane and left shoulder were constructed on March 17, 1995 and the surfacing in the travel lane (which is the test section) was paved on March 18, 1995. For section 04B901, the passing lane and left shoulder were constructed on March 19, 1995 and the test section in the travel lane was paved on March 25, 1995. The delay was due to the supply of PG76-10 asphalt cement.

Detailed in this section of the report are the hot-mix plant, the paving equipment utilized, and the paving sequencing used to complete the operation. Normal paving equipment and techniques were utilized in the completion of these sections.

Hot-Mix Plant

All asphalt concrete was produced from one hot plant. The hot plant was a 1986 CMI Drum Dryer with a counter flow drum and a bag house.

Paving Equipment

All three sections were constructed utilizing the same equipment. The material was placed using a Blaw Knox PF220 rubber tired paver with a Barber-Greene extendable screed and a Barber-Greene pickup machine. The mat was compacted utilizing two 25-ton Dynapac Double Drum Vibratory Rollers and a 12-ton Rex Steel and Rubber Tired Static Roller. Listed in table 5 are the equipments which comprised the paving operation.

Table 5. Equipment used during asphalt concrete placement.

Equipment Type	Paving Description
Haul Trucks	Bottom Dumps
Pick-up Machine	Barber-Greene Pick-up Machine
Paver	Blaw-Knox PF-220 (Rubber Tire)
Breakdown Roller	DynaPac 25-ton Double Drum Vibratory
Intermediate Roller	DynaPac 25-ton Double Drum Vibratory
Finish Roller	12-ton Rex Steel and Rubber Tired Static Roller

Paving Sequencing

The placement for all three sections was similar. The passing lane and inner shoulder was placed first leaving a 2:1 longitudinal joint near centerline. The test section was placed 4-m wide with a 3:1 tapered joint at the outside edge. The 3 m outside shoulder was placed at a later date. The mat was placed at a 95-mm nominal depth to obtain a 76-mm compacted depth.

The existing mat was tacked with CSS-1h Emulsion at an application rate of 0.37 l/m^2 and had a 50 percent dilution rate. The tack was placed the day of paving and was always allowed time to break prior to paving.

The material was hauled to the site in bottom dump trucks and windrowed in front of the paver. The material was picked up and placed with the paver. The pickup of the material was very good and left very little material on the existing mat. The flow of material into the hopper was fairly consistent; however, there were times when the hopper was overloaded and also short of material. The gradation of this material leaves an open mat behind the paver and is prone to segregation; however, this was minimal. There was an occasional spot area of segregation and a continual segregation line at the center of the screed. The center of the screed segregation was probably due to wear on the kicker paddles on the auger while the spot segregation was not readily identifiable. The paver operated at approximately 13.7 m per minute and continually had to stop to wait for haul trucks. Every time the paver stopped, a transverse screed line was visible in the mat and may have some affect on the ride.

The mat was compacted in the following manner: the breakdown roller (25-ton double drum vibratory) made two passes vibratory and two passes static. The intermediate roller (25-ton double drum vibratory) made one pass vibratory and three passes static. The finish roller (12-ton steel and rubber) made five passes static. The rolling pattern was established on the passing lane and indicated, as the temperature rose during the day, that rollers would have to hold back due to shoving of the mat. This thickness held temperatures for a considerable time; however, all compaction rolling was completed by the time the mat reached 80°C. The amplitude and frequency of the rollers could not be determined as the gauges on both machines were not working and a reed tachometer was not available. The longitudinal joint was compacted in the following manner: the first pass of the breakdown (vibratory) was made entirely on the new mat leaving approximately 76 mm of uncompacted material at the joint.

The second pass (vibratory) was made placing the roller approximately 51 mm onto the adjacent cold mat and thereby compacting the 76-mm gap. The vibratory effort on the adjacent cold mat appeared to mark the 51-mm area some, but did not appear to create any major problems. The finished joint looked good for such a course material. The rollers did not have any problem keeping up with the paver.

Material Sampling and Testing

Numerous samples were collected during construction. Many samples were collected by the contractor for quality control purposes, other samples were collected by Arizona DOT for quality assurance purposes, and still others were collected solely for experimental testing purposes. The sampling and testing described in this section pertains only to those additional samples that were required for the SPS-9 testing.

The required material tests can be divided into five categories:

- Material Verification
- Mixture Design Conformation
- Quality Control Tests
- As-Built Tests
- Performance Prediction Tests

Each category is further divided into multiple individual tests. Tables 6-10 provide a listing of the tests required. Arizona DOT was responsible for performing these required tests.

CONSTRUCTION NOTES

During paving, Nichols Consulting Engineers, Chtd. (NCE) staff were on-site to collect detailed construction notes. However, due to time and budget constraints, detailed construction notes were only recorded for the three LTPP test sites. The purpose was not to serve as inspectors, but rather to document the operations. All inspection and acceptance was the responsibility of Arizona DOT.

Typical information recorded during paving included weather conditions, air temperature, mat temperature, equipment, methods, materials, and uncompacted thickness measurements. Generally, the uncompacted thickness measurements were recorded using a metal rod, which was pushed through the paving mat immediately behind the paver, then the depth of rod penetration was recorded. Pavement mat temperatures were recorded using a hand-held infrared thermometer.

Documented below are the construction operations on each of the three experimental sections.

Table 6. Material verification tests.

Test Name	Test Designation	Test Protocol
Aggregate Tests		
Aggregate Gradation	AG04	LTPP P14
Specific Gravity of Coarse Aggregate	AG01	LTPP P11
Specific Gravity of Fine Aggregate	AG02	LTPP P12
Specific Gravity of -200 Material	--	AASHTO T100
Coarse Aggregate Angularity	--	Penn DOT TM 621
Fine Aggregate Angularity	--	ASTM C1252
Toughness	--	AASHTO T96
Soundness	--	AASHTO T104
Deleterious Materials	--	AASHTO 112
Clay Content	--	AASHTO T176
Thin, Elongated Particles	--	ASTM D 4791
Asphalt Cement		
Penetration @ 5°C	--	AASHTO T49
Penetration @ 25° & 46°C	AE02	LTPP P22
Viscosity @ 60° & 135°C	AE05	LTPP P25
Specific Gravity @ 16°C	AE03	LTPP P23
Dynamic Shear @ 3 Temperatures	--	AASHTO TP5
Brookfield Viscosity @ 135° & 165°C	--	ASTM D4402
Rolling Thin Film Oven (RTFOT)	--	AASHTO T240
Dynamic Shear on RTFOT Residue @ 3 Temperatures	--	AASHTO TP5
Pressure Aging (PAV) of RTFOT Residue	--	AASHTO PP1
Creep Stiffness of RTFOT-PAV Residue @ 2 Temperatures - 24-Hour Conditioning	--	AASHTO TP1
Creep Stiffness of RTFOT-PAV Residue @ 2 Temperatures	--	AASHTO TP1
Dynamic Shear on RTFOT-PAV Residue @ 3 Temperatures	--	AASHTO TP5
Direct Tension on RTFOT-PAV Residue @ 2 Temperatures	--	AASHTO TP3

Table 7. Mixture design conformation tests.

Test Name	Test Designation	Test Protocol
Mixed and Compacted HMA		
Gyratory Comp. @ Design Asphalt Content at N_{max}	--	AASHTO M-002
Gyratory Comp. @ 3% AV(lab samples)	--	AASHTO M-002
Gyratory Comp. @ 7% Air Voids	--	AASHTO M-002
Bulk Specific Gravity	AC02	LTPP P02
Maximum Specific Gravity	AC03	LTPP P03
Asphalt Content (Extraction) (Uncomp. Material)	AC04	LTPP P04
Aggregate Gradation (Extracted Aggregate)	AG04	LTPP P14
Moisture Susceptibility	AC05	LTPP P05
Volumetric Calculations		
Volume Percent of Air Voids	--	AASHTO PP19
Percent Voids in Mineral Aggregate	--	AASHTO PP19
Voids Filled with Asphalt	--	AASHTO PP19

Table 8. During placement nonstandard quality control tests.

Test Name	Test Designation	Test Protocol
HMA Specimen Compaction		
Gyratory Comp. @ N_{max}	--	AASHTO M-002
Volumetric Tests		
Bulk Specific Gravity	AC02	LTPP P02
Asphalt Content (Extraction)	AC04	LTPP P04
Aggregate Gradation (Extracted Aggregate)	AG04	LTPP P14
Maximum Specific Gravity	AC03	LTPP P03
Volumetric Calculations		
Volume Percent of Air Voids	--	AASHTO PP19
Percent Voids in Mineral Aggregate	--	AASHTO PP19
Voids Filled with Asphalt	--	AASHTO PP19

Table 9. As-built material tests from cores.

Test Name	Test Designation	Test Protocol
Core Examination/Thickness	AC01	LTPP P01
Volumetric Analysis		
Bulk Specific Gravity	AC02	LTPP P02
Asphalt Content (Extraction)	AC04	LTPP P04
Aggregate Gradation (Extracted Aggregate)	AG04	LTPP P14
Volumetric Calculations		
Volume Percent of Air Voids	--	AASHTO PP19
Percent Voids in Mineral Aggregate	--	AASHTO PP19
Voids Filled with Asphalt	--	AASHTO PP19
Recovered Asphalt Cement		
Abson Recovery	AE01	LTPP P21
Penetration @ 5°C	--	AASHTO T49
Penetration @ 25° & 46°C	AE02	LTPP P22
Viscosity @ 60° & 135°C	AE05	LTPP P25
Specific Gravity @ 16°C	AE03	LTPP P23
Dynamic Shear @ 3 Temperatures	--	AASHTO TP5
Creep Stiffness @ 2 Temperatures	--	AASHTO TP1
Direct Tension @ 2 Temperatures	--	AASHTO TP3

Table 10. Performance prediction tests to be performed by Superpave Regional Test Center.

Test Name	Test Designation	Test Protocol
LTPP Performance Tests by LTPP Contract Laboratory		
Indirect Tensile Strength	AC07	LTPP P07
Resilient Modulus	AC07	LTPP P07
Creep Compliance	AC06	LTPP P06
Superpave Shear Tester Performance Tests by Superpave Regional Test Center		
Frequency Sweep at Constant Height & Simple Shear at Constant Height	SST-1	AASHTO M-003, P-005
Volumetric Test & Uniaxial Strain	SST-2	AASHTO M-003, P-005
Repeated Shear at Constant Stress Ratio	SST-3	AASHTO M-003, P-005
Superpave Indirect Tensile Tests by Superpave Regional Test Center		
Indirect Tensile Creep Compliance & Indirect Tensile Strength	SP-IT	AASHTO M-005

Section 04B901 - Agency Standard Mixture

The passing lane and left shoulder for section 04B901 were constructed on March 19, 1995 and the test section in the travel lane was constructed on March 25, 1995. The delay was due to the supply of PG76-10 asphalt cement. The weather for construction of section 04B901 was somewhat cooler than other two sections. The air temperature was around 16°C.

The section was paved utilizing the rubber tired paver and there was segregation at the centerline of the paver. The contractor did some adjustment on the screed after the section was placed and this created a much more open mat on the left 0.9 m of screed for the remaining paving that day.

Section 04B902 and 04B903 - Superpave Level 1 Mixture

The actual test sections of the travel lane were constructed on March 18, 1995, one day after the passing lane and left shoulder were constructed. The weather was warm ranging from 21°C to 30°C.

A section of the travel lane between section 04B902 and 04B901 (outside of any test area) was placed with a tracked Blaw Knox paver which left a different texture on the surface of this section and there were also additional problems with segregation. This was paved a day prior to placing section 04B901 and the contractor was stopped approximately 152-m short of this section due to an aggregate gradation problem.

SUMMARY

Three SPS-9A test sections were constructed in March of 1995 conforming to the requirements of the LTPP SPS-9A experimental guidelines and six agency supplemental sections were constructed for ADOT research purposes. The nine test sections were constructed on Interstate 10 westbound lanes between milepost 112.72 and 112.29. The pavement structure consisted of 76 mm of asphalt concrete placed over 102 mm large stone inlay of the existing pavement structure.

All test sections are located between project stations 5945+00 and 6448+00. Superpave level 1 mixture design criteria were utilized to design two of the three sections. The agency standard section was designed using the Marshall 75 blow mixture design method. Asphalt binder in each of the three sections varied. A performance-graded binder, PG76-10 was utilized on the Superpave section, a PG70-10 was used in the alternate binder section, and a PG76-10 asphalt cement was used in the agency standard section.

Typical construction practices were utilized throughout the project and no deviations from the experimental guidelines were evident. The air temperature during placement was between 16°C and 30°C. No measurable precipitation was received during placement.

Post construction testing revealed the final thicknesses were nearly identical between all three sections and matched the design thickness. Also, gradations and asphalt contents were very near the design values.

No major deficiencies, either due to materials or construction, were identified. Therefore, this project should prove to be an excellent experiment in meeting the SPS-9A experimental objectives.

REFERENCE

1. SHRP Superpave Level 1 Mix Designs for Oglesby Road - Perryville Road, Project (I-10), Final Report, Applied Paving Technology, Inc., Houston, TX, November 1995.